REMARKS

This is intended as a full and complete response to the Office Action dated May 15, 2006, having a shortened statutory period for response extended by one month and set to expire on September 15, 2006. Please reconsider the claims pending in the application for reasons discussed below.

Claims 8-10, 20-22, 31-33, and 37-59 remain pending in the application and are shown above. Claims 8-10, 20-22, 31-33, and 37-59 remain rejected by the Examiner. Reconsideration of the rejected claims is requested for reasons presented below.

Claims 42, 44, 51, 57, and 59 stand rejected under 35 U.S.C. § 112, first paragraph, as failing to comply with the written description requirement. Claims 44 and 59 have been amended to comply with the written description requirement. The Applicant respectfully traverses the rejection of claims 42, 51, and 57.

The Examiner asserts that "a thickness of less than about 200 Å," as recited in claims 42, 51, and 57, is new matter previously not disclosed in the application. However, the application discloses on page 14, paragraph 37:

> "The copper seed layer is deposited to a thickness in a range from about 50 Å to about 300 Å. In one aspect, the thickness is about 300 Å or less, preferably at about 200 Å or less and more preferably, at about 100 Å or less."

Therefore, the specification does support "a thickness of less than about 200 Å," as recited in claims 42, 51, and 57.

Withdrawal of the rejection is respectfully requested.

Claims 8-10, 20-22, 31-33, and 37-59 stand rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claims 8, 20, 31, 44, and 59 have been amended to clarify the claimed subject matter. The Applicant respectfully traverses the rejection of claim 22.

The Examiner asserts that "the first copper solution" as recited in line 2 of claim 22 lacks an antecedent basis. However, claim 20, from which claim 22 ultimately depends from, recites "a first copper solution," at line 12.

Withdrawal of the rejection is respectfully requested.

Claims 8-9, 20-21, 31-32, 37-58 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Miura et al., U.S. Pub. No. 2003-0155247, herein, *Miura*, in combination with Dubin et al., U.S. Pat. No. 6,432,821, herein, *Dubin* and Wang et al., U.S. Pat. No. 6,528,412, herein, *Wang*. The Examiner asserts that the claimed invention would have been obvious to one having ordinary skill in the art by modifying *Miura* in combination with *Dubin* and *Wang*. The Applicant respectfully traverses the rejection.

Miura discloses a process which provides the deposition of a tantalum nitride barrier layer using a sputtering technique, the deposition of a copper seed layer using a sputtering technique, and the application of electrolytic copper plating to fill or half fill trenches or via holes on the substrate. (see [0059] to [0061]). The Examiner asserts that *Miura* "teaches a method for ***depositing*** a copper-containing seed layer (= ***reinforces*** the seed layer and ***adds thickness to the seed layer*** within the trenches or via holes) [page 4, [0051]] onto a barrier material layer (= a barrier layer) [page 3, [0049]]." (Office Action mailed 05/15/06, page 9).

The Federal Circuit has mandated that "[a] prior art reference is relevant for ***all that it teaches*** to those of ordinary skill in the art." *In re Fritch*, 23 U.S.P.Q.2d 1780, 1782 (1992) (*emphasis added*). It follows that it is unfair for the Examiner the misconstrue the disclosure of *Miura*, which does not teach electroplating a copper seed layer onto a barrier material. Accordingly, *Miura* discloses that a "conductive ***seed layer is deposited*** on the surface of silicon wafer, or inside the trenches or via holes, ***prior to*** application of ***electrolytic copper plating***." The seed layer is deposited by a PVD technique or a CVD technique. (see [0049] to [0050]). *Miura* clearly deposits the seed layer by PVD or CVD prior to electrolytic copper plating. Subsequently, *Miura* begins an electrolytic copper plating process in order to reinforce and add thickness to the seed layer. (see [0051]). The evidence proffered by the Examiner is inadequate to support the assertion that the ***seed layer deposited on the surface of a silicon wafer by PVD or CVD techniques prior to the application of electrolytic copper plating***, as disclosed by *Miura*, is equivalent to ***a method for depositing a copper-containing seed layer onto a barrier material layer by an electroplating technique***.

Furthermore, the Examiner has admitted that "Miura teaches that the ***seed layer*** is formed by depositing a layer of a highly conductive metal (e.g., copper) using PVD techniques such as sputtering and ion plating or CVD techniques." (Office Action mailed 05/15/06, page 11, paragraph 3).

Dubin discloses a process to force a first forward current, a second forward current, and a third forward current for depositing an initiation layer, a feature fill layer, and a bulk layer. The process disclosed by *Dubin* includes sequential reverse current steps within a single copper plating solution. The same chemical components are maintained throughout the various steps disclosed by *Dubin*.

Wang discloses a process for forming an adhesion skin layer containing a metal alloy doping element on an underlying material (e.g., barrier or dielectric) prior to forming a seed enhancement layer on the adhesion skin layer and a copper fill layer on the seed enhancement layer. The Examiner asserts that the invention would have been obvious because the seed layer may be discontinuous, as taught by *Wang*, and the electrolytic copper plating disclosed by *Miura* "would have applied an electrical bias to deposit ***a copper seed layer (= an enhancement seed layer)*** on the barrier surface." (Office Action mailed 05/15/06, page 12, paragraphs 1-2). The Applicant respectfully disagrees with the Examiner's assertion.

The Examiner asserts that the copper seed layer of *Miura* is equivalent to the enhancement layer of *Wang*. However, *Wang* describes throughout the Background that "because the seed enhancement layer 130 is formed by an ECD (electrochemical deposition) ... ***the seed enhancement layer 130 does not adhere as well as the seed layer 122*** ... The poor adhesion of the seed enhancement layer 130 ... is more likely to result in disadvantageous electromigration failure of the interconnect. On the other hand, a relative thick seed layer 124 has overhang 124 ... which is more likely to result in disadvantageous void formation within the interconnect." (paragraph 3, lines 13-36). *Wang* overcomes the "as known to one of ordinary skill in the art of integrated circuit fabrication," by forming "a thin adhesion skin layer including a metal alloy doping element" on the underlying material prior to forming a seed layer thereon. *Wang* clearly distinguishes between a seed enhancement layer and a seed layer. The Examiner has

failed to show a clear and particular motivation by the skilled artisan to combine *Miura* and *Wang*.

On this point, the Federal Circuit has ruled that "[o]ne cannot use hindsight reconstruction to pick and choose among isolated disclosures in the prior art to deprecate the claimed invention." (*In re Fritch* at 1784). In order to avoid using the Applicant's disclosure as a blueprint to pick and choose certain elements, while ignoring others, the Examiner must supply a clear and particular motivation or suggestion to do so. In the present case, the Examiner must show a clear and particular motivation, of one skilled in the art, to combine the deposition of a seed layer onto a barrier layer by *Miura* with the teaching away of *Wang*, which provides depositing ***a thin adhesion skin layer*** including ***a metal alloy doping element*** between the barrier layer and the seed layer. Otherwise, the true motivation is forbidden hindsight.

Therefore, *Miura*, *Dubin*, and *Wang*, alone or in combination, do not teach, show, or suggest a method for depositing a copper-containing seed layer onto a barrier layer, comprising providing a substrate comprising the barrier layer disposed on a substrate surface, wherein the barrier layer has a barrier surface selected from the group consisting of a tungsten surface, a tungsten nitride surface, a titanium surface, a titanium nitride surface, a cobalt surface, a ruthenium surface, a nickel surface, and a silver surface, exposing the substrate to a first copper solution containing complexed copper ions and having a pH value of less than 7, wherein the complexed copper ions are derived from a copper source selected from the group consisting of copper citrate, copper borate, copper tartrate, copper oxalate, derivates thereof, and combinations thereof, applying a first electrical bias across the substrate surface to chemically reduce the complexed copper ions and to deposit a copper seed layer onto the barrier surface and depositing a copper gap-fill layer by exposing the substrate to a second copper solution containing free-copper ions, and applying a second electrical bias across the substrate surface to deposit the copper gap-fill layer onto the copper seed layer, as recited in claim 8, and claims 9 and 37-44 dependent thereon.

Also, *Miura*, *Dubin*, and *Wang*, alone or in combination, do not teach, show, or suggest a method for depositing a copper-containing seed layer onto a barrier layer, comprising providing a substrate comprising the barrier layer disposed on a substrate

surface, wherein the barrier layer has a barrier surface selected from the group consisting of a tungsten surface, a tungsten nitride surface, a titanium surface, a titanium nitride surface, a cobalt surface, a ruthenium surface, a nickel surface, and a silver surface, exposing the substrate to a complexed copper solution containing complexed copper ions reducing the complexed copper ions with a first electrical bias to form a copper seed layer on the barrier surface, and depositing a copper gap-fill layer by exposing the substrate to a first copper solution containing free-copper ions, and applying a second electrical bias across the substrate surface to deposit the copper gap-fill layer onto the copper seed layer, as recited in claim 20, and claims 21 and 45-52 dependent thereon.

Also, *Miura*, *Dubin*, and *Wang*, alone or in combination, do not teach, show, or suggest a method for depositing a copper-containing seed layer onto a barrier layer, comprising providing a substrate comprising the barrier layer disposed on a substrate surface, wherein the barrier layer has a barrier surface selected from the group consisting of a tungsten surface, a tungsten nitride surface, a titanium surface, a titanium nitride surface, a cobalt surface, a ruthenium surface, a nickel surface, and a silver surface, exposing the substrate to a complexed copper solution containing complexed copper ions derived from a copper source selected from the group consisting of copper citrate, copper borate, copper tartrate, copper oxalate, derivates thereof, and combinations thereof, reducing the complexed copper ions with a first electrical bias to form a copper seed layer on the barrier surface, wherein the first electrical bias has a current density of less than about 10 mA/cm^2 across the substrate surface, and depositing a copper gap-fill layer by exposing the substrate to a second copper solution containing free-copper ions, and applying a second electrical bias across the substrate surface to deposit the copper gap-fill layer onto the copper seed layer, as recited in claim 31, and claims 32 and 53-58 dependent thereon.

Withdrawal of the rejections is respectfully requested.

Claims 10, 22, and 33 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Miura*, in combination with *Dubin* and *Wang*, as applied to reasons discussed above, and further in view of Nagai et al., U.S. Pat. No. 6,709,563, herein

Nagai. The Examiner asserts that the claimed invention would have been obvious to one having ordinary skill in the art by modifying *Miura* in combination with *Dubin* and *Wang*, and in further view of *Nagai*. The Applicant respectfully traverses the rejection.

Miura, *Dubin*, and *Wang* have been discussed and distinguished above.

Therefore, *Miura*, *Dubin*, *Wang*, and *Nagai*, alone or in combination, do not teach, show, or suggest a method for depositing a copper-containing seed layer onto a barrier layer, comprising providing a substrate comprising the barrier layer disposed on a substrate surface, wherein the barrier layer has a barrier surface selected from the group consisting of a tungsten surface, a tungsten nitride surface, a titanium surface, a titanium nitride surface, a cobalt surface, a ruthenium surface, a nickel surface, and a silver surface, exposing the substrate to a first copper solution containing complexed copper ions and having a pH value of less than 7, wherein the complexed copper ions are derived from a copper source selected from the group consisting of copper citrate, copper borate, copper tartrate, copper oxalate, derivates thereof, and combinations thereof, applying a first electrical bias across the substrate surface to chemically reduce the complexed copper ions and to deposit a copper seed layer onto the barrier surface and depositing a copper gap-fill layer by exposing the substrate to a second copper solution containing free-copper ions, and applying a second electrical bias across the substrate surface to deposit the copper gap-fill layer onto the copper seed layer, as recited in claim 8, and claim 10 dependent thereon.

Also, *Miura*, *Dubin*, *Wang*, and *Nagai*, alone or in combination, do not teach, show, or suggest a method for depositing a copper-containing seed layer onto a barrier layer, comprising providing a substrate comprising the barrier layer disposed on a substrate surface, wherein the barrier layer has a barrier surface selected from the group consisting of a tungsten surface, a tungsten nitride surface, a titanium surface, a titanium nitride surface, a cobalt surface, a ruthenium surface, a nickel surface, and a silver surface, exposing the substrate to a complexed copper solution containing complexed copper ions reducing the complexed copper ions with a first electrical bias to form a copper seed layer on the barrier surface, and depositing a copper gap-fill layer by exposing the substrate to a first copper solution containing free-copper ions, and applying a second electrical bias across the substrate surface to deposit the copper

gap-fill layer onto the copper seed layer, as recited in claim 20, and claim 22 dependent thereon.

Also, *Miura*, *Dubin*, *Wang*, and *Nagai*, alone or in combination, do not teach, show, or suggest a method for depositing a copper-containing seed layer onto a barrier layer, comprising providing a substrate comprising the barrier layer disposed on a substrate surface, wherein the barrier layer has a barrier surface selected from the group consisting of a tungsten surface, a tungsten nitride surface, a titanium surface, a titanium nitride surface, a cobalt surface, a ruthenium surface, a nickel surface, and a silver surface, exposing the substrate to a complexed copper solution containing complexed copper ions derived from a copper source selected from the group consisting of copper citrate, copper borate, copper tartrate, copper oxalate, derivates thereof, and combinations thereof, reducing the complexed copper ions with a first electrical bias to form a copper seed layer on the barrier surface, wherein the first electrical bias has a current density of less than about 10 mA/cm^2 across the substrate surface, and depositing a copper gap-fill layer by exposing the substrate to a second copper solution containing free-copper ions, and applying a second electrical bias across the substrate surface to deposit the copper gap-fill layer onto the copper seed layer, as recited in claim 31, and claim 33 dependent thereon.

Withdrawal of the rejections is respectfully requested.

Claim 59 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over *Miura*, in combination with *Dubin* and *Wang*, as applied for reasons discussed above, and in further view of Dubin, U.S. Pub. No. 2004-0108217, herein *Dubin '217*. The Examiner asserts that the claimed invention would have been obvious to one having ordinary skill in the art by modifying *Miura* in combination with *Dubin* and *Wang*, and in further view of *Dubin '217*. The Applicant respectfully traverses the rejection.

Miura, *Dubin*, and *Wang* have been discussed and distinguished above.

Therefore, *Miura*, *Dubin*, *Wang*, and *Dubin '217*, alone or in combination, do not teach, show, or suggest a method for depositing a copper-containing seed layer onto a barrier material layer, comprising providing a substrate having a ruthenium barrier layer disposed on a substrate surface, exposing the substrate to a first copper solution

containing complexed copper ions and having a pH value of less than 7, applying a first electrical bias across the substrate surface to chemically reduce the complexed copper ions and to deposit a copper seed layer onto the ruthenium barrier layer, and depositing a copper gap-fill layer by exposing the substrate to a second copper solution containing free-copper ions, and applying a second electrical bias across the substrate surface to deposit the copper gap-fill layer onto the copper seed layer, as recited in claim 59.

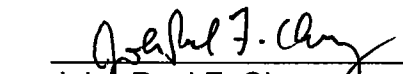
Withdrawal of the rejection is respectfully requested.

In conclusion, the references cited by the Examiner, alone or in combination, do not teach, show, or suggest the claimed invention.

Having addressed all issues set out in the Office Action, the Applicant respectfully submits that the claims are in condition for allowance and respectfully request that the claims be allowed.

If the Examiner would like to further discuss the present application, please feel free to directly call the Applicant at 713.577.4828.

Respectfully submitted,



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PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a) FY 2005 *(Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818).)*	Docket Number (Optional) APPM/008241/PPC/ECP/CKIM
Application Number 10/616,097	Filed July 8, 2003
For Multi-Step Electrodeposition Process for Direct Copper Plating on Barrier Materials	
Art Unit 1753	Examiner Edna Wong

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

	Fee	Small Entity Fee	
☒ One month (37 CFR 1.17(a)(1))	$120	$60	$120.00
☐ Two months (37 CFR 1.17(a)(2))	$450	$225	$_____
☐ Three months (37 CFR 1.17(a)(3))	$1020	$510	$_____
☐ Four months (37 CFR 1.17(a)(4))	$1590	$795	$_____
☐ Five months (37 CFR 1.17(a)(5))	$2160	$1080	$_____

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☒ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 20-0782/APPM/008241/JPC .

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant/inventor.

☐ assignee of record of the entire interest. See 37 CFR 3.71
Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96).

☐ attorney or agent of record. Registration Number _____

☒ attorney or agent under 37 CFR 1.34.

Registration number if acting under 37 CFR 1.34. 57,323 .

Signature	September 15, 2006
	Date
John-Paul F. Cherry	713-623-4844
Typed or printed name	Telephone Number

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below.

☐ Total of _____ forms are submitted.